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for

INTRUSION PREVENTION FOR ACTIVE NETWORKED APPLICATIONS

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INTRUSION PREVENTION FOR ACTIVE NETWORKED APPLICATIONS

FIELD OF THE INVENTION

5 [0001] This invention relates generally to computer security, and more particularly to intrusion prevention.

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BACKGROUND OF THE INVENTION

20 [0003] Threats to networked computers from hostile network traffic are becoming more and more serious. Compounding the problem is the increase in known vulnerabilities to widely used network applications. Particular attacks, such as Code Red and Nimda, exploit application vulnerabilities and hostile network traffic to compromise and damage systems. Existing technologies that perform both network-based and host-based intrusion detection or intrusion prevention on a computer or workstation examine all network traffic for all known attacks they have been configured to detect. However, because networks are

getting faster, and the number of attacks to detect is constantly growing, the processing required by current intrusion detectors is increasing in two dimensions. Eventually, all other processes may be denied the use of the computer since all the processing resources will be consumed by the intrusion detection or intrusion prevention system.

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SUMMARY OF THE INVENTION

[0004] Intrusion prevention for a computer is based on intrusion rules corresponding to active networked applications executing on the computer. The intrusion rules are a subset of a full ruleset that may include signatures of known attacks or heuristic rules. The subset changes as network connections for active applications are initiated and terminated, or as the active applications terminate.

[0005] The present invention describes systems, methods, and computer-readable media of varying scope. In addition to the aspects of the present invention described in this summary, further aspects will become apparent by reference to the drawings and by reading the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 is a diagram illustrating a system-level overview of an embodiment of the invention;

Figure 2 is a flowchart of a method to be performed by a computer according to an embodiment of the invention;

Figure 3A is a diagram of one embodiment of an operating environment suitable for practicing the present invention; and

Figure 3B is a diagram of one embodiment of a computer system suitable for use in the operating environment of Figure 3A.

DETAILED DESCRIPTION OF THE INVENTION

5 [0007] In the following detailed description of embodiments of the invention, reference is made to the accompanying drawings in which like references indicate similar elements, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other
10 embodiments may be utilized and that logical, mechanical, electrical, functional, and other changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

[0008] An overview of the operation of an embodiment of the invention is described by

15 reference to Figure 1 in which an intrusion prevention system 100 executes on a computer to detect hostile traffic transmitted between a network 109 and applications active on the computer. Intrusion prevention typically relies on pattern matching network traffic against known attack “signatures.” For example, the header of a TCP/IP packet may be malformed to exploit a known limitation in the operating system. An intrusion rule may
20 also describe an attack that takes place at a higher level on the protocol stack. For example, an attack that is based on a malformed (or extremely large) HTTP request. The attack signature is stored in a intrusion rule which may contain other information about the attack, such as what application it targets, the signature of the specific hostile payload, and/or what network ports and protocol it uses. An intrusion rule also may be a heuristic

rule that cannot be defined by specific characteristics. For example, a heuristic rule may describe an attack that is based on unusual behavior, e.g., an application suddenly making a new, previously unseen connection, or suddenly initiating a larger number of connections. Standard sets of intrusion rules (“rulesets”) are commonly available from vendors of intrusion detection/intrusion prevention systems and may be modified to be specific to the computer. Alternatively, some or all of the intrusion rules can be created by an administrator or user of the computer.

[0009] The system 100 applies a filter 103 based on the active networked applications 105 to a full ruleset 107 so only those intrusion rules corresponding to the active networked applications are used to evaluate 101 incoming and outgoing network traffic. If incoming or outgoing network traffic matches a rule in the filtered ruleset, the intrusion prevention system 100 discards the hostile traffic and reports the intrusion attempt. In one embodiment, the system 100 reports the attempt by logging the incident and/or triggering an alert. When the filtered ruleset includes the particular network ports used by the attacks, the system 100 evaluates only network traffic through the specified network ports. For intrusion rules that define attacks on connectionless protocols (i.e. ICMP), the network traffic at the appropriate protocol level is analyzed.

[0010] In one embodiment, the filter 103 marks the appropriate entries in the full ruleset 107. In an alternate embodiment not shown, the filter 103 extracts the appropriate intrusion rules into an optimized ruleset, which is used to evaluate subsequent network traffic. Such an optimized ruleset could be generated by querying a database for intrusion rules pertaining to only the current active applications. The result of such a query would return a database “view” or “snapshot” which in turn would be used as the “current” ruleset.

[0011] It will be appreciated that the set of active networked applications 105 changes as application connections to the network 109 are initiated or terminated. In one embodiment, the system 100 determines when an active application initiates a network connection by intercepting “listen” commands directed to the operating system. The

5 system 100 also monitors for inbound connections to an active, but not currently networked application. A list of active applications may be obtained using various operating system services. An application is removed from the set of active networked applications 105 when it becomes inactive, i.e., the application, or its last network connection, has terminated.

[0012] The intrusion prevention system 100 may operate as a stand-alone security system or may operate as part of, or in conjunction with, an existing security system, such as a software firewall. The system 100 may perform analysis for specific protocols, including analysis of specific protocol-level payloads. In an alternate embodiment, the system 100 does not attempt to evaluate application data within the network traffic, deferring the

10 detection of hostile code, such as email viruses, to other security applications.

[0013] Because the intrusion rules for applications not currently active, or active applications not currently connected to the network 109, are ignored, the intrusion prevention system 100 requires, on average, less processing resources than intrusion detection/intrusion prevention systems that evaluate network traffic for all known attacks.

[0014] Next, a method to be performed by a computer in accordance with one embodiment of the invention is described in terms of computer software with reference to a flowchart shown in Figure 2. The method constitutes computer programs made up of computer-executable instructions. Describing the method by reference to a flowchart enables one skilled in the art to develop such programs including such instructions to carry out the

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methods on suitably configured computers (the processor of the computer executing the instructions from computer-readable media). The computer-executable instructions may be written in a computer programming language or may be embodied in firmware logic. If written in a programming language conforming to a recognized standard, such instructions

5 can be executed on a variety of hardware platforms and for interface to a variety of operating systems. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the invention as described herein.

Furthermore, it is common in the art to speak of software, in one form or another (e.g.,
10 program, procedure, process, application, module, logic...), as taking an action or causing a result. Such expressions are merely a shorthand way of saying that execution of the software by a computer causes the processor of the computer to perform an action or produce a result. It will be further appreciated that the acts described in conjunction with Figure 2 are not required to be performed in the particular order shown and that the

15 processes of the invention may be divided into more or fewer logical blocks than those shown.

[0015] An intrusion prevention system (IPS) method 200 shown in Figure 2 is typically invoked when the host computer is booted. As part of its initialization process, the method 200 determines the operating system for the computer (block 201) and obtains the full
20 ruleset (203) pertinent to the computer hardware and operating system (block 203). The currently active networked applications are determined (block 205) and the corresponding intrusion rules in the full ruleset are marked (block 207).

[0016] The main processing of the method 200 is represented by two threads in Figure 2. An evaluation thread processes incoming and outgoing network traffic against the marked

intrusion rules and handles hostile traffic as described in conjunction with Figure 1 (block 215). A watch thread intercepts the initialization and termination of network connections for active applications (block 209). When a network connection is initiated for an active application, the method 200 marks the corresponding rules (block 211). When the last

5 network connection for an application is terminated, the method 200 unmarks the corresponding intrusion rules (block 213). In an alternate embodiment, at block 209 the watch thread intercepts the termination of an active application instead of the termination of the network connections for the active application.

[0017] In an alternate embodiment not shown, the evaluation thread represented by block 10 215 is deactivated when the last networked application terminates its networked connection and is reactivated upon when the method 200 detects the initiation of a network connection. It will be appreciated that the method 200 may postpone activating the evaluation thread if no active networked applications are found at block 205. In yet another embodiment not shown, processing represented by block 207, 211 and 213 creates

15 an optimized ruleset as described above in conjunction with Figure 1.

[0018] The following description of Figures 3A-B is intended to provide an overview of computer hardware and other operating components suitable for implementing the invention, but is not intended to limit the applicable environments. One of skill in the art will immediately appreciate that the invention can be practiced with other computer

20 system configurations, including hand-held devices, multiprocessor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. The invention can also be practiced in distributed computing environments where tasks are performed by remote processing

devices that are linked through a communications network having a physical or wireless infrastructure, or a combination of both.

[0019] Figure 3A shows several computer systems that are coupled together through a network 3, such as the Internet. The term "Internet" as used herein refers to a network of networks which uses certain protocols, such as the TCP/IP protocol, and possibly other protocols such as the hypertext transfer protocol (HTTP) for hypertext markup language (HTML) documents that make up the World Wide Web (web). The physical connections of the Internet and the protocols and communication procedures of the Internet are well known to those of skill in the art. Access to the Internet 3 is typically provided by Internet service providers (ISP), such as the ISPs 5 and 7. Users on client systems, such as client computer systems 21, 25, 35, and 37 obtain access to the Internet through the Internet service providers, such as ISPs 5 and 7, through either physical or wireless interfaces. Access to the Internet allows users of the client computer systems to exchange information, receive and send e-mails, and view documents, such as documents which have been prepared in the HTML format. These documents are often provided by web servers, such as web server 9 which is considered to be "on" the Internet. Often these web servers are provided by the ISPs, such as ISP 5, although a computer system can be set up and connected to the Internet without that system being also an ISP as is well known in the art.

[0020] The web server 9 is typically at least one computer system which operates as a server computer system and is configured to operate with the protocols of the World Wide Web and is coupled to the Internet. Optionally, the web server 9 can be part of an ISP which provides access to the Internet for client systems. The web server 9 is shown coupled to the server computer system 11 which itself is coupled to web content 10, which

can be considered a form of a media database. It will be appreciated that while two computer systems 9 and 11 are shown in Figure 4A, the web server system 9 and the server computer system 11 can be one computer system having different software components providing the web server functionality and the server functionality provided by the server computer system 11 which will be described further below.

[0021] Client computer systems 21, 25, 35, and 37 can each, with the appropriate web browsing software, view HTML pages provided by the web server 9. The ISP 5 provides Internet connectivity to the client computer system 21 through the modem interface 23 which can be considered part of the client computer system 21. The client computer system can be a personal computer system, a network computer, a Web TV system, a handheld wireless device, including an Internet-capable cellular phone, or other such computer system. Similarly, the ISP 7 provides Internet connectivity for client systems 25, 35, and 37, although as shown in Figure 4A, the connections are not the same for these three computer systems. Client computer system 25 is coupled through a modem interface 27 while client computer systems 35 and 37 are part of a LAN. While Figure 4A shows the interfaces 23 and 27 as generically as a "modem," it will be appreciated that each of these interfaces can be an analog modem, ISDN modem, cable modem, satellite transmission interface (e.g. "Direct PC"), radio frequency (RF), cellular, or other interfaces for coupling a computer system to other computer systems. Client computer systems 35 and 37 are coupled to a LAN 33 through network interfaces 39 and 41, which can be Ethernet network or other network interfaces. The LAN 33 is also coupled to a gateway computer system 31 which can provide firewall and other Internet related services for the local area network. This gateway computer system 31 is coupled to the ISP 7 to provide Internet connectivity to the client computer systems 35 and 37. The gateway computer

system 31 can be a conventional server computer system. Also, the web server system 9 can be a conventional server computer system.

[0022] Alternatively, as well-known, a server computer system 43 can be directly coupled to the LAN 33 through a network interface 45 to provide files 47 and other services to the clients 35, 37, without the need to connect to the Internet through the gateway system 31.

[0023] Figure 3B shows one example of a conventional computer system that can be used as a client computer system or a server computer system or as a web server system. It will also be appreciated that such a computer system can be used to perform many of the functions of an Internet service provider, such as ISP 5. The computer system 51 interfaces to external systems through the modem or network interface 53. It will be appreciated that the modem or network interface 53 can be considered to be part of the computer system 51. This interface 53 can be an analog modem, ISDN modem, cable modem, token ring interface, satellite transmission interface (e.g. "Direct PC"), radio frequency (RF), cellular, or other interfaces for coupling a computer system to other

computer systems. The computer system 51 includes a processing unit 55, which can be a conventional microprocessor such as an Intel Pentium microprocessor or Motorola Power PC microprocessor. Memory 59 is coupled to the processor 55 by a bus 57. Memory 59 can be dynamic random access memory (DRAM) and can also include static RAM (SRAM). The bus 57 couples the processor 55 to the memory 59 and also to non-volatile storage 65 and to display controller 61 and to the input/output (I/O) controller 67. The display controller 61 controls in the conventional manner a display on a display device 63 which can be a cathode ray tube (CRT) or liquid crystal display. The input/output devices 69 can include a keyboard, disk drives, printers, a scanner, and other input and output devices, including a mouse or other pointing device. The display controller 61 and the I/O

controller 67 can be implemented with conventional well known technology. A digital image input device 71 can be a digital camera which is coupled to an I/O controller 67 in order to allow images from the digital camera to be input into the computer system 51.

The non-volatile storage 65 is often a magnetic hard disk, an optical disk, or another form

5 of storage for large amounts of data. Some of this data is often written, by a direct memory access process, into memory 59 during execution of software in the computer system 51. One of skill in the art will immediately recognize that the term “computer-readable medium” includes any type of storage device that is accessible by the processor 55 and also encompasses a carrier wave that encodes a data signal.

10 **[0024]** It will be appreciated that the computer system 51 is one example of many possible computer systems which have different architectures. For example, personal computers based on an Intel microprocessor often have multiple buses, one of which can be an input/output (I/O) bus for the peripherals and one that directly connects the processor 55 and the memory 59 (often referred to as a memory bus). The buses are connected together
15 through bridge components that perform any necessary translation due to differing bus protocols.

[0025] Network computers are another type of computer system that can be used with the present invention. Network computers do not usually include a hard disk or other mass storage, and the executable programs are loaded from a network connection into the
20 memory 59 for execution by the processor 55. A Web TV system, which is known in the art, is also considered to be a computer system according to the present invention, but it may lack some of the features shown in Figure 3B, such as certain input or output devices. A typical computer system will usually include at least a processor, memory, and a bus coupling the memory to the processor.

[0026] It will also be appreciated that the computer system 51 is controlled by operating system software which includes a file management system, such as a disk operating system, which is part of the operating system software. One example of an operating system software with its associated file management system software is the family of operating systems known as Windows[®] from Microsoft Corporation of Redmond, Washington, and their associated file management systems. The file management system is typically stored in the non-volatile storage 65 and causes the processor 55 to execute the various acts required by the operating system to input and output data and to store data in memory, including storing files on the non-volatile storage 65.

[0027] Intrusion prevention based on active networked applications has been described. Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiments shown. This application is intended to cover any adaptations or variations of the present invention.

[0028] For example, those of ordinary skill in the art will appreciate that while the invention has been described in terms of intrusion prevention software executing on the processing unit of the computer the software is protecting, the present invention is equally capable of executing as firmware for a hardware card, such as an add-in firewall board, that interfaces with the operating system of the computer. Furthermore, it will be appreciated that the invention is applicable to all types of networks including public and private, wide area and local area, wireless and wired. Therefore, it is manifestly intended that this invention be limited only by the following claims and equivalents thereof.